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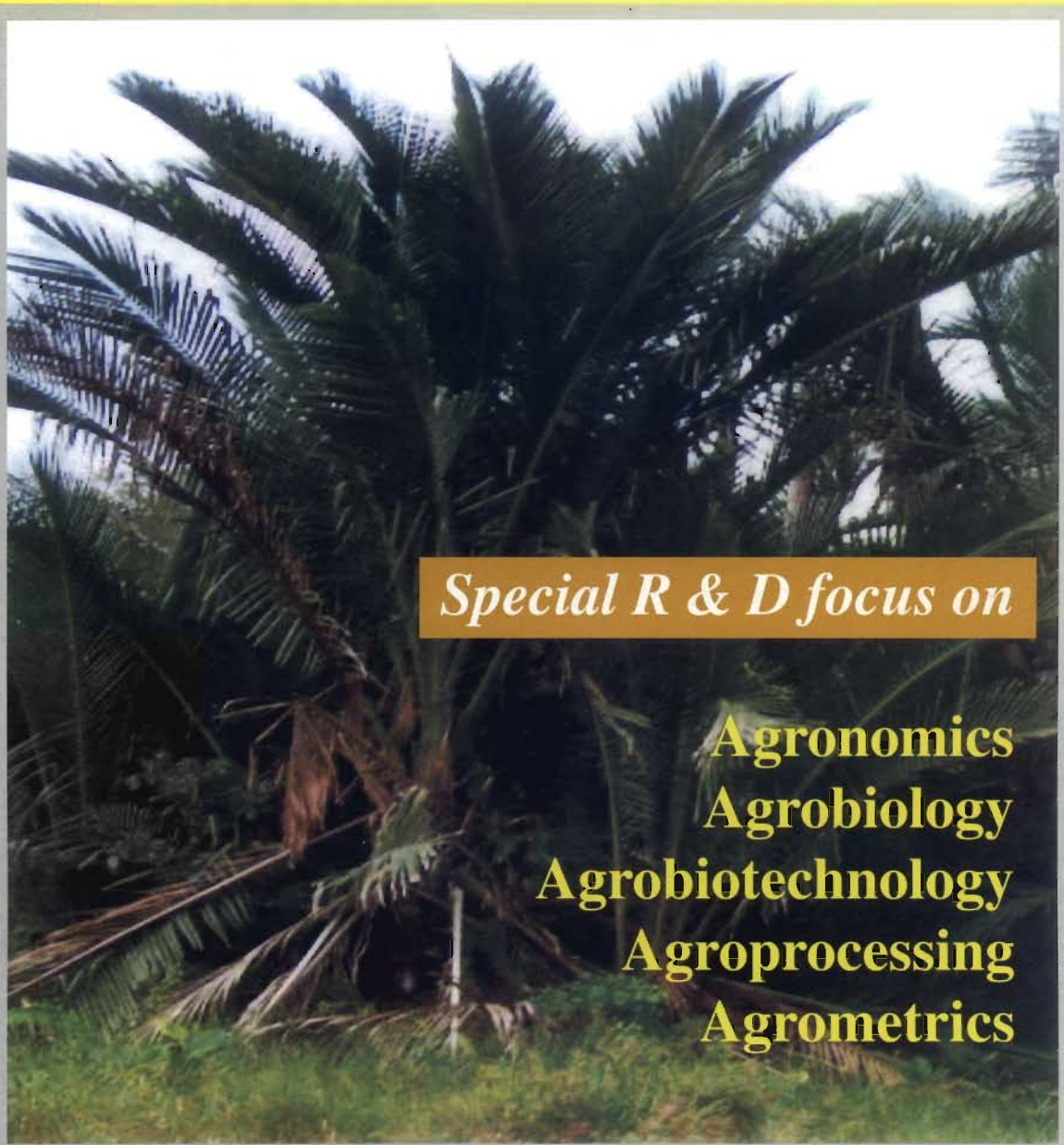


UNIVERSITI MALAYSIA SARAWAK
UNIMAS

FOREWORD

This edition of Research Update highlights a broad range of agriculture related research undertaken by the academic staff of Unimas. The importance of this area of research cannot be over-emphasized given the earnest interest of the Government to promote and expedite the growth of agricultural sector as one of the mainstream production sectors in Malaysia.

Much of the research activities in the area of agronomics, agrobiology and agrobiotechnolgy have been spearheaded by the researchers of the Faculty of Resource Science and Technology. Numerous fundings have been secured to support these areas research; these include the EU grants, IRPA grants (MOSTI), Fundamental Research grants (MoHEd), FELDA, private sectors and other various funding sources.

These research activities have been pursued with close cooperation with end-users, from state-owned agencies (e.g. LCDA, SALCRA) and private companies (e.g. Malesiana Tropicals Sdn Bhd) with indirect participation and support of several other government agencies such as the Department of Agriculture and the Department of Drainage and Irrigation.

An important spin-off benefit derived from the EU support studies on peat soils and peatland management is an exciting international networking with several academic and research institutions in countries such as The Netherlands, UK, Germany, Finland and Indonesia. These and other research projects have indeed enhanced the global outlook amongst the researchers of Unimas and reinforced the academic fraternity within their respective field of specialization.

It is the interest of Unimas to remain relevant in its research endeavors. As such, research in agricultural domain will remain a thrust area at this university in support of the stakeholders' needs in terms of education and training as well as creation and development of new knowledge and technologies in this sector. This should establish the reputation of Unimas as a dynamic research and educational centre in the field of agrobiology, agronomics, agrobiotechnology and other similar areas.

Prof Murtedza Mohamed
Director
Research and Innovation Centre (RIMC)
Unimas

Content

THE AGRONOMIC RESPONSES OF PLANTATION CROPS TO PEAT SOILS OF VARYING DEGREE OF HUMIFICATION

Humification is an important process during the decomposition of organic materials in organic soils where humic substances form and non-humic substances decompose. As decomposition process progresses, the percentage of humic substances is expected to increase relative to the total organic matter. These compounds are extremely important soil component because they constitute a stable fraction of carbon, regulating the carbon cycle and the release of nutrients, including nitrogen, phosphorus and sulphur. Additionally, they improve water holding capacity, pH buffering and thermal insulation. Humic acids are reported to increase the permeability of plant membranes thus promoting the uptake of nutrients. Apparently, young peat depresses the plant growth. Oxygen is critical for healthy root development. Planting on young peat creates an antagonistic relationship between plants and soils. The young peat is consuming oxygen for decomposition thus exerts a negative influence on oxygen supply to the roots. Old peat on the other hand has smaller particles, limiting the hydraulic conductivity and in turn increases water-holding capacity. Newly developed peat is still very porous. It tends to increase the leaching of the nutrients leading to imbalance between nitrogen and potassium. A field investigation has inferred that the sapric-hemic-fibric morphology in peat is necessary for the successful cultivation of crops. Sapric and hemic layers, the more humified fractions, provide necessary rooting medium and anchorage which is otherwise absent in the fibric materials. In Sarawak, most of the peat soils is characterized by an irregular complex of poorly decomposed woody materials. It is possible that the productivity of cultivation on peat is hindered by the maturity which is reflected by its degree of humification. A thorough study on the degree of humification in relation to plant growth is therefore essential to provide insights on the succession of crops on the indigenous peat. The objectives of this study are to study the degree of humification for peat and plant growth under oil palm plantation at different ages and water tables; sago at different ages and water tables and forest plantation at different ages and water tables.

Researchers

Khadijah Khalid (UiTM), Sim Siong Fong (Unimas), Murtedza Mohamed (Unimas)

Supporting Grant

Fundamental Research Grant No. 01(76)/407/2003(144)

CHRONOLOGAL INFLUENCE OF WATER TABLE ON THE OXIDATION RATE OF ORGANIC SOILS

A study was carried out to determine the oxidative loss of organic soil in relation to water table by observing and correlating changes in the physico-chemical properties over 18 months of exposure. It was hypothesized that there could be a threshold or optimal water table whereby the physico-chemical integrity of peat material can be reasonably prolonged. The study was based on an ex-situ approach using the lysimeter experimental set-up of laboratory scale. Replicates of homogenised organic soils were left standing over 0, 30, 60 and 90 cm water table in PVC columns for 18 months. Soil samples were then removed and analyzed at 3-monthly intervals to determine changes in its physical and chemical properties over time. Parameters analysed were subsidence, bulk density, moisture content, total ash content, pH, redox potential, electrical conductivity, rubbed fibre content, total organic carbon, FTIR spectroscopy, pyrophosphate index, and humic acids. The analyses were based on the methods of physical and chemical analysis for organic soils prescribed in the USDA soil methods manual and also in the DOA Sarawak manual for soil analysis. The observed changes were correlated with the depth of water table. The analytical results obtained in this study were generally in agreement with those reported by earlier physical and chemical studies on tropical organic soils. Physical properties changed considerably under the influence of water level. Subsidence was the most pronounced whereby the 90 cm water table column appeared to have resulted in a cummulative subsidence by more than 50 % against that observed in the 30 cm water table column. Other physical characteristics that changed during the exposure were bulk density, RFC and moisture content. Changes of physical attributes in organic soil was influenced most by moisture content. The lower water table would cause the organic soil to dry and shrink extensively. This had resulted in subsidence and increased in bulk density due to compaction and consolidation. Certain chemical properties also showed considerable changes after prolonged exposure. The 90 cm water table soil column lost 23 % of organic substrates over 6 months of exposure whereas the 30 cm water table lost only 21 % over 18 months of exposure. The higher water table showed less changes compared to the lower water tables. Based on the results of pyrophosphate index and the correlation between rubbed fibre content and optical density the degree of decomposition was found to be significant. Thus the physico-chemical properties of peat material was influenced greatly by the exposure of soil column above the water table to oxidation. The study indicates that even with the best water managent, subsidence and variations of physico-chemical characteristics cannot be completely arrested once peatland is drained. Nevertheless, the rate of these changes can be reduced to extend the life span of organic soils. The present study illustrates that maintaining water table at 30 cm or less can effectively slow down the rate of changes, at least in terms of subsidence and loss of organic matter.

Researchers
Lip Khoon Kho, Murtedza Mohamed and Wan Sulaiman Wan Harun

Supporting Grant
Fundamental Research Grant No. 01/23/300/2002(37)

ECOPHYSIOLOGICAL STUDY OF *METROXYLON SAGU* IN SARAWAK

Sago palm *(Metroxylon sagu)* is traditionally cultivated in floodplains of alluvial and shallow peat along rivers for commercial purposes as well as for general consumption. This is especially true of the Melanau community in Mukah District. They represent the principal sago growers and consumers of Sarawak. It is normally planted in small scale as to obtain good management system for high crop production as well as taking several benefit of this situation; the peat here are shallower than those further inland and better suited for palm growth; transporting the harvested trunks can be floated down to the processing points; planting liable to flooding; good soil fertility and the pest problems possibly kept under control. In 1987 Land Custody and Development (LCDA) took major task in establishing large scale planting to transform sago palm as one of the major plantation crops in the country. The growth performance with excellent partition of biomass for trunk formation depends greatly on the favourable environmental conditions, edaphic suitability and efficient water management as well as proper agronomic practices. Good selection of planting materials, effective planting system and appropriate fertilizer application according to the crop requirement also plays important role to ensure satisfactory harvesting of sago products. To date there is lack of information on the assessment of above ground biomass and other vegetative characteristic studies such measurement of leaf area, leaf area index, root dynamic, photosynthetic rate and interrelationship of these factors.

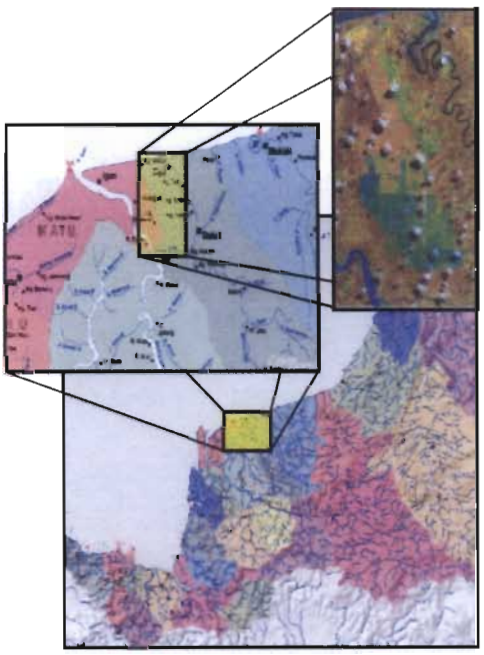
Researchers

Isa Ipor (Unimas), Noraini Basri (CRAUN), Petrus Bulan (Unimas) and Wan Sulaiman Wan Harun (Unimas).

Supporting grant

CRAUN

COMPARATIVE STUDY ON GROUND WATER CHARACTERISTICS OF TRUNKING AND NON-TRUNKING SAGO PALMS



Sarawak has large coverage of peat soils which are classified as marginally suitable to unsuitable for agriculture purpose. This is due to the major constraints of peat soil such as high acidity, low nutrient contents, slow mineralisation rate, poor drainage due to high water table, low bulk density and bearing capacity, as well as subsidence upon drainage. Hence peat soils are basically problematic soils which are considered uneconomical for agriculture utilization. However, due to scarcity of inland mineral soils and the Sarawak Government policy of emphasizing agriculture sector in export-oriented industries, the development of agriculture on peat soils became a necessity. Based on the fact that sago was a major cash and cultural crop, and the assumption that it can grow well on peat, a first sago plantation was initiated at Mukah-Dalat District. However, after more than ten years of planting, the trunking rate of the sago palms was still low. This study focused on the influence of ground water regime and its properties on the growth of sago palms. The finding revealed that there were differences between the water table, pH, conductivity and nitrate content in the ground water of the trunking and non-trunking sago palms. The trunking sago palms generally grow on shallower water table, having less acidic, higher conductivity and nitrate content ground water. The actual interactions of these factors and how they have an effect on sago growth characteristics are unclear. It is suggested that by introducing proper water management that is able to control the fluctuation of ground water to the favourable level, the growth of sago palms can be improved.

Researchers
Liew, S.H., Wan Sulaiman Wan Harun

Supporting grant
DANIDA SLUSE M Env Mgt Project

Publication
Dissertation in the MSc SLUSE-M programme.

AN EXAMINATION OF THE CORRELATION BETWEEN PEAT SOIL CHARACTERISTICS AND THE GROWTH OF SAGO PALM *(METROXYLON SAGU)*

Development of peatland for large-scale agriculture is rapidly increasing in Sarawak, and sago palm is one of the most intensively cultivated crops on the largely deep peat areas in the coastal lowlands. Of late, a number of unanticipated problems in large-scale sago cultivation have been highlighted - one of which is the trunking ability of sago palms. This study attempts at examining the correlation between the physical and chemical properties of cultivated peat against the growth pattern of sago palms. For this purpose, soil samples, water table data and palm growth measurements were obtained and analysed for both trunking and non-trunking plantation blocks. The results revealed that the soils in the trunking blocks invariably contained higher levels of ash (minerals) and nutrients needed to support the normal growth and trunking of palms. These mineral and nutrient contents were found to decrease from the periphery to the center of peat dome. The productivity of cultivated palms was also compared against the degree of peat humification; no significant correlation was observed for these variables. The prevailing deficiency of nutrients in the soils of non-trunking blocks suggests that supplementary nutrient input is imperative.

Researchers
Asraff Julaihi Khan, Sim Siong Fong and Murtedza Mohamed

Supporting Grant
DANIDA SLUSE M Env Mgt Project

Publication
Dissertation in the MSc SLUSE-M programme.

COMPARATIVE STUDY OF MICROORGANISMS IN SOIL OF TRUNKING AND NON-TRUNKING SAGO PALM

This study is part of an umbrella study looking into factors influencing the growth patterns of sago palms under minimally managed peat swamp cultivation in Dalat, Sarawak. A comparative-inductive study design was applied to compare selected soil physicochemical and microbiological parameters such as soil pH, soil CO_2 emission and soil micrbiota, focusing on mycorrhizae and N_2 fixers, of soils samples collected from trunking and non-trunking sago palms. Two sampling plots at Dalat Sago Plantation (DSP) Phase 1A were identified and subjected to further study. Sago trunk volume was used as the index of trunking. During the duration of the study (September 2003 - January 2004), DSP was completely water-logged and its peat soil was very acidic (dry soil pH, 2.82-3.13). Using a field method of CO_2 detection by soda lime adsorption, soil CO_2 emission for trunking block was found to be significantly higher than non- trunking block. Total recoverable viable aerobic bacteria (TRVAB) counts for trunking block were marginally higher (80.46 % confident) than bacteria from non-trunking block. These data supported indicated that a higher CO_2 emission is attributed to the higher microbial population. Attempts at quantifying degree of mycorrhizal infection were unsuccessful due to the inability of the technique to distinguish between living and non-living roots. Enumeration of total aerobic N_2 fixers (TANF) did not reveal any significant difference between the TANF count for trunking and non-trunking palms. This suggested that most of the soil bacteria quantified were aerobic N_2 fixers, which were probably inactivated by the water-logging condition. Regression and partial correlation analysis have proven that the soil microbiological parameters were related to the trunk volume of the sago palm (r^2 = 1.000), p= 0.0008). TRVAB was found to be the most influential parameter. However, it was undermined by the high level of soil acidity. Therefore, under existing condition, soil pH seemed most important in affecting trunk volume. In light of these results, two soil amendments strategies are suggested, i.e the improvement of soil aeration by lowering the water table and increasing the soil pH by liming. However, soil microbiological interactions are so complex that the actual consequences of these amendments though very influential and significant, are quite unknown without further in-depth study into the subject.

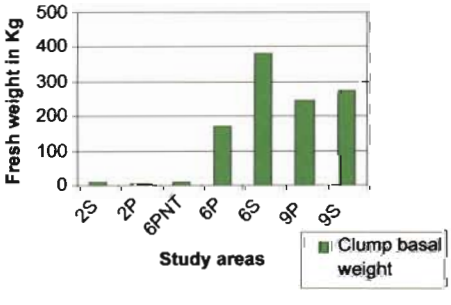
Researchers
Wong Ming Kui, Kasing Apun, Murtedza Mohammad

Supporting grant
SLUSE-M

Related publications

Wong Ming Kui (2004). MSc Thesis. Comparative study of microorganisms in soil of trunking and non-trunking sago palms plantation.

COMPARATIVE STUDY OF SAGO PALM IN SMALLHOLDING AND PLANTATION IN MUKAH AND DALAT
PART I: ABOVE GROUND BIOMASS



Sago palms in Sarawak's first three commercial sago plantations (Mukah Sago Plantation (MSP), Sebakong Sago Plantation (SSP) and Dalat Sago Plantation (DSP) on mainly deep peat) have very low productivity because of high seedling mortality rate, poor palm growths resulting in mostly senile palms with very poor ability to develop trunks - the very purpose for which sago plantations have been established. Good growth was only confined to a few areas, namely, on the shallower peat. This study explored the differences in partitioning pattern and photosynthetic capacity between trunking and non-trunking palms in the above plantations and smallholder plantings on shallow peat with a view of gaining a better understanding of factors that affect trunking of sago palms. This was done by destructive sampling of palm clumps at various growth stages in both the plantations and smallholdings. It was found that young palms (2 years old) in better managed smallholdings on shallow peat developed faster, producing bigger and taller mother palms as well as more suckers than those in the plantations on deep peat. Six and nine year old non-trunking palms in the plantations were comparable only to 2-years old palms in smallholdings in terms of overall development. At the early or rosette stage, the biomass allocation pattern favoured the formation of fronds and leaves. After trunk formation, increasingly larger proportions of dry matter were partitioned to the trunk such that in the well-developed mature trunking palms of smallholdings, trunks made up about one-third of the entire above-ground biomass of the clump. For the mother palm, its trunk constituted 40% of the biomass. Non-trunking plantation palms generally had low leaf area index (LAI), therefore, lower photosynthetic capacity. On the other hand, 9-years old trunking plantation palms (unpruned) had excessively high LAI leading to more non-productive or 'wasteful' biomass, and poorer sucker growth due to extra shading by mother palms. Trunking smallholding palms, through regular pruning, had intermediate LAI, and fewer but taller suckers with bigger girths. The above implies that harvesting intervals in a given clump will be longer in the plantation than in the smallholdings. Therefore, there is a need for a proper pruning programme in order to shorten trunk-maturing intervals and a corresponding increase in the plantation's trunk production. A desirable pruning programme could be one that culminates in mature trunking clumps having LAI of 10 - 12 ha/ha.

Researchers
Isa, I., Wan Sulaiman W.H., Bulan, P., and B. Noraini (CRAUN)

Supporting grant
Collaborative Research CRAUN-UNIMAS funded by LCDA.

COMPARATIVE STUDY OF SAGO PALM IN SMALLHOLDING AND PLANTATION IN MUKAH AND DALAT. PART II: ROOTS

Sago palms in Sarawak's first three commercial sago plantations (Mukah Sago Plantation (MSP), Sebakong Sago Plantation (SSP) and Dalat Sago Plantation (DSP) on mainly deep peat) have very low productivity because of high seedling mortality rate, poor palm growths resulting in mostly senile palms with very poor ability to develop trunks - the very purpose for which sago plantations have been established. Good growth was only confined to a few areas, namely, on the shallower peat. The main aim of this part of the study on the root distribution was to observe the nature of root system growth, locate and estimate their depths and concentrations in the soil. The knowledge derived on the root system will help in developing recommendations on appropriate system of fertilizer application or placement for each developmental stage of the sago palms. Sago palms have two different types of root: aerial root for absorbing oxygen from the atmosphere and feeder root for anchorage, and uptake of water and nutrients from the soil. The feeder roots spread out and down, positively geotropic, from the base of the palm. Palms that have trunked, especially those grown in smallholdings, had better developed root system than those that have not trunked, both in terms of lateral and vertical spread as well as density or concentration of feeder roots through to 60 cm depth. The number of roots was high in the direction of the L-shaped base of the trunk and increased with increase in the number of suckers per mother palm. The base of the trunk of palm trees which were trunking or were beginning to produce trunk were slightly large and had more and better established suckers. As a generalization, the zone of maximum root concentration extends out radially from the mother palm as the palm ages. For 2-3 years old palms, this zone of concentration is between 1m and 2m from the base of the mother palm. For 6 and 9 years old palms, this zone is between 3m and 5m away from the mother palm. For maximum fertilizer use efficiency, fertilizers should be applied in these concentric zones of maximum root concentration corresponding to the age of the palms/clumps.

Researchers
Bulan, P., Isa, I., Wan Sulaiman W.H., and B. Noraini (CRAUN)

Supporting grant
Collaborative Research CRAUN-UNIMAS funded by LCDA

COMPARATIVE STUDY OF SAGO PALM IN SMALLHOLDING AND PLANTATION IN MUKAH AND DALAT
PART III: SOIL STUDIES

This is the third part of a study to understand why most sago palms in Sarawak's commercial sago plantations did not trunk. It is predicated on the hypothesis that smallholdings on shallow peat in river floodplains experience seasonal rise and fall of water table that allows oxidation and humification of the peat. The process releases nutrients and develops a favourable medium that provides sago roots both in nourishment and anchorage. Large scale plantings of sago on deep peat, on the other hand, experience prolonged inundation and the thick floor mat of undecomposed plant residues provides neither physical support nor nourishment to the sago roots. Dry matter accumulation thus falls short of the norm for healthy palms, and insufficient to initiate trunk development (storage). Peat soils in the vicinity of trunking and non-trunking palms at various growth stages in the Mukah, Dalat and Sebakong Sago Plantations as well as in smallholdings were investigated by means of studied by in-situ measurements and laboratory analyses on samples taken from the sites. Results showed peat depth to be the single most visible factor associated with trunking and non-trunking status of the sago palms. Good trunking palms were all on shallow peat while the severely under-performing (non-trunking) palms were all on deep peat. Soils under trunking palms were more humified than those under non-trunking palms based on their higher bulk density and greater depletion of total nutrient contents. The severely under-performing palms also appeared to have been grown or established more on the root mat than on the soil proper. On moderately deep peat, more of trunking palms were located nearer the drain than away from it. The smallholdings were located near or along streams that allow natural drainage and recharge of groundwater. The above findings are very much consistent with the hypothesis that smallholder farms on shallow peat provide more favourable growing conditions for sago palms than the deep peats in the plantations. The higher bulk density of the more humified peat also improves nutrient absorption by roots due better soil-root contact. Foliar analysis showed all palms to contain sufficient N and Ca but somewhat lower levels of P, K and Mg compared to healthy palms grown on mineral soil elsewhere. The severely under-performing 9 years old non-trunking palms had very low B concentration. In the non-trunking palms, the low amount of dry matter accumulated all went to the internal maintenance of the crop followed by the production of fronds, leaves and suckers. None remained for development of storage organs (trunks)! As for trunking palms, their continuous withdrawing of nutrients caused rapid depletion of the nutrient pool in the peat soil that would not likely to be fully compensated through recycling, particularly after harvesting of trunks. Thus, an appropriate fertilization programme need to be developed to replenish the pool.

Researchers
Wan Sulaiman W.H., Isa, I., Bulan, P., and B. Noraini (CRAUN)

Supporting grant
CRAUN-UNIMAS funded by LCDA.

RESTORATION OF MUKAH PEAT THROUGH WATER TABLE MANAGEMENT

Sarawak has a total peatland area of about 1.675 million hectares, most of which are basin swamps located in the more populated coastal region. Coupled with the fact that non-peatland that is suitable for agriculture is very limited, a large portion (0.5 mill. ha) of these coastal basin peat swamps have either been utilized or alienated for agriculture. The large scale plantings of sago on the deep peats in the Mukah Division are one such agricultural land use. Drainage of peatland for agriculture inevitably leads to surface subsidence and gradual decline in the peatland's carbon store and other ecological functions. Indeed, this sets a limit to the agricultural lifetime of the peatland, i.e., when surface subsides to a level below the natural groundwater table of the surrounding areas. Strategies for sustaining or prolonging the life of the peatland include minimizing subsidence and maximizing carbon assimilation or biomass accumulation through vegetative growth. The aim of this project is to restore the hydrological integrity of the Mukah peat swamp so as to enable viable agricultural production on the deep peat and to evaluate the effectiveness of the water management regime for growth of sago palms. Studies will be conducted on various sites (pilot study areas) in the Dalat, Mukah and Sebakong Sago Plantations. Activities planned to achieve the overall aim include the following:

a. Topographic, soil and peat depth survey, and installation of water table monitoring device
b. Studies on temporal changes in the physical, chemical and biological properties of the peat soil, and
c. Studies on performance of sago palms and estimation of total biomass accumulation in pilot study areas

Researchers

Wan Sulaiman W.H., Murtedza M., N. Hafsah

Supporting grant

European Union INCO Contract No. 510931

Related publication

Noraini B., Wan Sulaiman W.H., Isa I., and P. Bulan (2004). Comparative Study of Sago Palm in Smallholding and Plantation in Mukah and Dalat - Ecophysiological Responses to Different Edaphic Conditions. CRAUN Technical Report.

MOLECULAR ANALYSIS OF THE STARCH BIOSYNTHESIS PATHWAY IN SAGO PALM

The starch biosynthesis in sago pathway involves four major enzymes, namely ADP-glucose pyrophosphorylase (AGPase), starch synthase (SS), starch-branching enzyme (SBE) and starch-debranching enzyme (SDE). AGP forms ADP-glucose from glucose 1-phosphate. SS adds ADP-glucose to the elongation end of an α-(1-4)-linked glucose chain, whereas SDE cuts α(1-4)-links and rejoin them as α(1-6) branches that are subsequently trimmed by DBE to yield short chains for further synthetic extension. A study aimed at determining the genetic and biochemical mechanisms involved in starch biosynthesis in the sago palm has been initiated. The main objective is to isolate and characterize the genes that code for the four key enzymes mentioned above. The research work involves the application of molecular and biotechnological techniques including PCR, gene screening, cloning and DNA sequencing. To date a near-complete 1755-base pair cDNA sequence of granule-bound SS (GBSS) and partial cDNA sequences specific for soluble SS (824-bp), AGPase (400-bp), SBE (1200-bp) and SDE (480-bp) enzymes have been obtained. The near complete GBSS cDNA codes for 505 amino acids and shares high homology with GBSS genes from several crop plants including rice, maize and wheat. Sequence comparison showed that it is truncated at the 5'-end. PCR-screening of genomic library using specific primers derived from this sequence led to the identification of a 3,865-bp genomic locus for this gene. The structural organization and complete nucleotide sequence of this locus has been determined. It contains 12 exons and 11 introns but the significance of this structure in its expression and regulation is still unknown. A complete analysis of the structure, organization and regulation of the above genes would lead to a full understanding of the starch biosynthesis process in the sago plant. This in turn would enable genetic modifications to be carried out to produce new sago varieties with higher yields or those that can synthesize modified forms of starch for various applications.

Researchers

Mohd Azib Salleh, Mohd Hasnain Hussain, Hairul Azman, Jennifer Lau Siew Kee, Bala ak Jamel and Hwang Siaw San.

Supporting Grant

MALAYSIA TORAY SCIENCE FOUNDATION Researh Grant (2001-2003); UNIMAS Fundamental Research Grants Nos. 234/2000(25) & 01(113)487/2004(224).

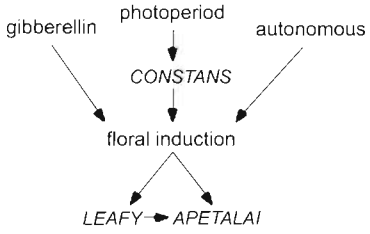
Selected Publications

Salleh, M A and J S K Lau (2003). Identification and characterization of a genomic DNA sequence coding for granule-bound starch synthase in sago palm, *Metroxylon, sagu*. In *Biotechnology for Sustainable Utilization of Biological Resources in the Tropics* (Y Murooka, ed.) Vol 16: 43-50.

Jamel B, M Morshidi & M A Salleh (2001). Identification of molecular markers in sago palm (*Metroxylon sagu*) using polymerase chain reaction. *Asia-Pacific Journal of Molecular Biology and Biotechnology* 9(1): 71-74.

Salleh M A, B Jamel, SK Bong & JSK Lau (2000) Molecular studies on the starch biosynthesis pathway of the sago palm, *Metroxylon sagu*. In *Biotechnology for Sustainable Utilisation of Biological Resources in the Tropics* (Yoshida T et al, eds) Vol 14: 8-15.

ISOLATION AND CHARACTERISATION OF LEAFY- AND CONSTANS-LIKE GENES IN SAGO PALM



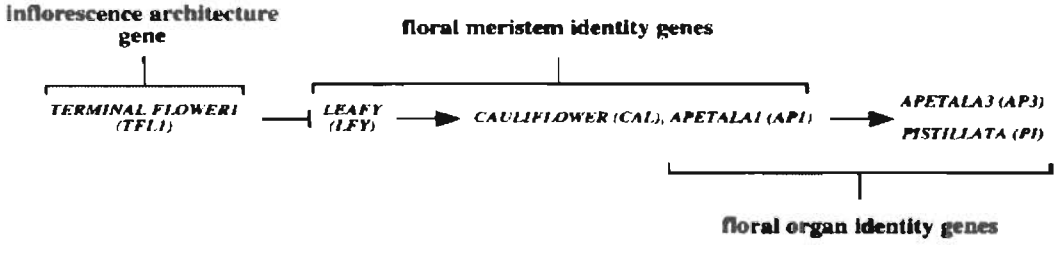
Sago palm is a plant in the genus Metroxylon. The name metroxylon is derived from Greek words; 'metra' means "pith" and 'xylon' means "xylem". Sago palm is a "once-flowering" plant where during vegetative stage carbohydrates are accumulated in the plants. Following the final reproductive stage where the plant's food reserves are expended for the production of inflorescence, flowers and then fruits and the palm dies. Sago palm takes a long time to mature and subsequently produce flower that can take between 10-14 years. Traditionally, planters have used the flowering stage as an indicator for logging to occur. This is because the starch content is increased and modified just before the flowering stage. The characterisation of genes and factors that are involved in the initial phase of the flowering process could give an indication on how the factors interact. Researches in the plant model, *Arabidopsis thaliana,* have shown that the flowering process involves the transformation from a vegetative form (apical meristem) to a floral form (floral meristem). The transformation can take place through three pathways; gibberellin, autonomous and photoperiod pathways. CONSTANS (CO) is adaptive gene that is involved in the photoperiod pathway and involved in the timing of flowering. CO acts as a transcriptional activator and is upregulated during initiation of flowering stage, either directly or indirectly, activating the floral meristem identity gene LEAFY. LEAFY is a gene that is directly involved in the transcription activation of the Floral Homeotic Gene Group that determines the development of inflorescence. Preliminary works have been initiated in UNIMAS that involved PCR screening of various degenerate primers based on the LEAFY and LEAFY-like genes. We have managed to generate a reproducible fragment specific to LEAFY genes in sago palm. Further funding for the project is being sought. The overall purpose of this research is to look if there is any interaction between the onset of flowering and the starch accumulation in sago palm.

Researchers

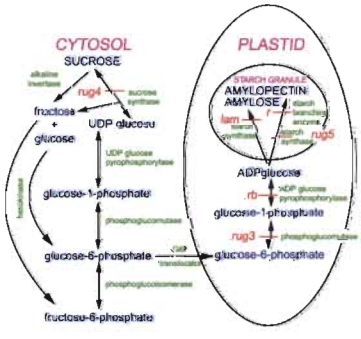
Hairul Azman Roslan, Mohd Hasnain Mohd Hussain (Unimas)

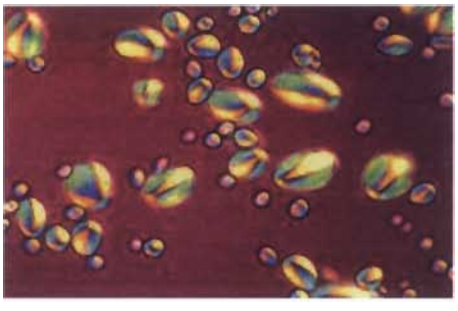
Supporting grant

IRPA EAR grant (Application Pending)



ISOLATION OF THE LARGE SUBUNIT OF THE ADP-GLUCOSE PYROPHOS-PHORYLASE GENE





The sago palm *(Metroxylon sagu)* can be found in abundance in the freshwater swamps of Southeast Asia. In the state of Sarawak, this palm is grown as a starch crop for its ability to produce between two to five tons of dry starch per hectare in the wild and ten to twenty-five tons per hectare in cultivated areas. Sago is popularly grown as a commercial crop on smallholdings in Sarawak, exporting over 50 000 tons of air-dried flour a year. Apart from starch being used as food, sago starch can be used as adhesives in paper, textiles and plywood, or as stabilizers in pharmaceuticals. New uses and ideas for sago include in biodegradable plastics, biopolymer plastics, high fructose syrup and ethanol. Starch consist of glucose polymers and abundant in the plant kingdom. The site of accumulation varies such as in the plastids and also in the storage organs. Starch is made of 2 polysaccharide namely the amylose and amylopectin. Amylose is a simple polysaccharide, linear in form. Meanwhile amylopectin is highly complex consisting of branched polysaccharides. Various enzymes are involved in the biosynthesis of starch such as ADP-glucose pyrophosphorylase (AGPase), starch synthase, starch branching and debranching enzymes. AGPase is one of the key enzymes in the biosynthesis of starch in higher plants. In plants, this enzyme is heterotetrameric composing of two small and two large subunits. The AGPase enzyme is the first committed step that catalyses the formation of ADP-glucose from glucose-1-phosphate in the starch biosynthetic pathway. Similarly in sago, this enzyme plays an important role in the flux of starch production. It has been suggested that there are at least three types of AGPase polypeptides: one small subunit that is found in both the photosynthetic and non-photosynthetic tissues; and two large subunits that is found exclusively in each non-photosynthetic and photosynthetic tissues. In this project, the initiating genes involved in starch synthesis, the AGPase, will be isolated. Currently the mRNA from leaves and pith cells are being extracted. The cDNA will then be synthesised by the use of polymerase chain reaction (PCR). The genomic and cDNA sequences will be determined to further understand the biosynthesis of starch in sago palm.

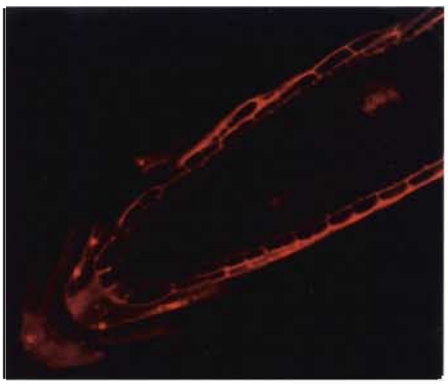
Researchers

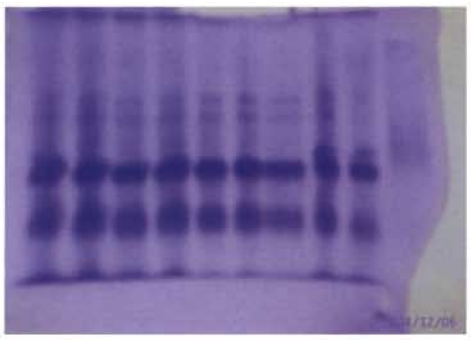
Hairul Azman Roslan, Mohd Azib Salleh, Patricia Chong Ing Pei (Unimas)

Supporting grant

UNIMAS Fundamental Research Grant 01(84)/424/2004(161)

IDENTIFICATION AND CHARACTERISATION OF WATERLOG TOLERANT GENES IN SAGO PALM





Flooding is a worldwide phenomenon in wetland and river areas. Excess water in the soil could produce anoxic soil condition. This will in turn produce either a complete or partial submergence of roots. Subsequently the roots suffer hypoxia or anoxia. Most plants are obligate aerobes and needs constant supply of oxygen for function. Disruption of this supply could result in reduced phloem transport and depletion of carbohydrates in roots, decrease in stomatal aperture that regulates photosynthesis, wilting of leaves, reduced mitochondria integrity and other anaerobic responses. Plants are resilient and have evolved to overcome the flooding phenomenon. Various adaptation, physically and physiologically, are activated. Proteins are produced in response to the low- or no-oxygen conditions to the roots. The physiological ability of plants to convert its metabolism into a low- or no- oxygen condition enables it to tolerate waterlogging. The main ability of tolerance is to switch to an ethanolic fermentation in the roots. In an aerobic condition, sugars are broken down to form pyruvate and used in the tricarboxylic acid cycle (TCA) to produce 4 ATP, 10 NADH and 2 FADH2. The product is then used for respiration to produce 34 ATP, 10 NAD+ and 2 FAD with each oxygen molecule. Sago palms in Sarawak can be found on mainly swampy/waterlogged areas. These plants seemed to be able and have evolved a system in which to overcome the anoxic/hypoxic conditions of the roots. Previous researches have shown that plants are able to adapt the low-/no- oxygen conditions by switching its metabolism of pyruvate to ethanolic pathways. During alcoholic fermentation, Adh seemed to be one of the main enzymes produced with a high concentration and production of Adh corresponds to ethanol production in flood-tolerant and intolerant plants. Currently we have managed to isolate proteins that are present in waterlogged and non-waterlogged roots, leaves and pith cells. Characterisation of Adh isozyme was undertaken using polyacrylamide gel electrophoresis. This project will identify and characterise the number of Adh loci that is present in sago palm and subsequently isolate the genes and factors regulating Adh expression.

Researchers
Hairul Azman Roslan, Yasotha Sundaraj (Unimas)

Supporting grant
UNIMAS Fundamental Research Grant 01(84)/424/2004(161)

LARGE-SCALE PRODUCTION AND PURIFICATION OF L-LACTIC ACID FROM SAGO STARCH

The emergence of new markets for application of lactic acid such as biodegradable thermoplastics together with the more traditional industries such as tanning of leather, pharmaceuticals, food and beverages and cosmetics (skin care, toiletries, hair care products) have created an impetus for the lactate industries to grow into a larger scale. Large-scale fermentation processes has always been plagued by expensive substrates which poses a serious hindrance in promoting lactic acid industries. It is therefore imperative for such processes to utilize renewable and alternative sources to reduce production costs. Previous research have shown the possibilities of using natural rubber serum powder (NRSP) or natural rubber serum concentrate (NRSC) as an alternative to yeast extract. Locally, sago starch can be used as the cheap substrate for lactate production. Sago palm, which grows in swamp areas inhabitable for most other crops is also the world's highest starch producer, at 25t/ha/year. Sago starch can be developed either as a substrate for production of glucose or this can be fermented to generate L-lactic acid. At 98% recovery, hydrolysis of sago starch into glucose is a sensible alternative since glucose (US$0.34/kg) fetch a higher price to sago starch (US$0.20/kg), and the conversion process cost only about US$10/t. Fermentation studies have been carried out to achieve maximum lactate production by *Lactococcus lactis* IO-1 on enzymatically hydrolyzed sago starch producing 0.96g/g lactate, a 96% conversion of glucose into lactic acid. At US$60/litre, conversion to lactic acid will certainly add further value to sago starch. In our laboratory, lactic acid is purified using powdered activated charcoal in glass columns layered with glass wool. Lactate recovery is over 98% with excellent removal of color (99%), glucose (100%) and protein (98%). Conclusively, we have shown the economic feasibility of converting sago starch to glucose and subsequently to lactic acid at almost 1:1 ratio as the new value added product from the sago industry of Sarawak.

Researchers

Kopli Bujang (Unimas), Ayaaki Ishizaki (New Century Fermentation Research), Yoshiyuki Nomura (Sojo University, Kumamoto, Japan); J.M. Lopez-Real (Imperial College, University of London)

Supporting grant

New Energy and Industrial Technology Development Organization (NEDO) L18403 FO7; IRPA 09 02 09 1024 EA001; IRPA 08-02-09-1023 EA001

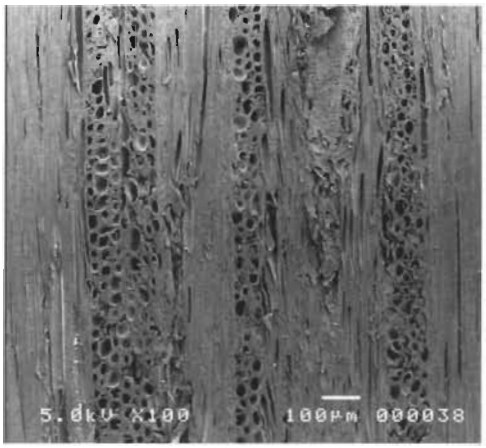
Related publications

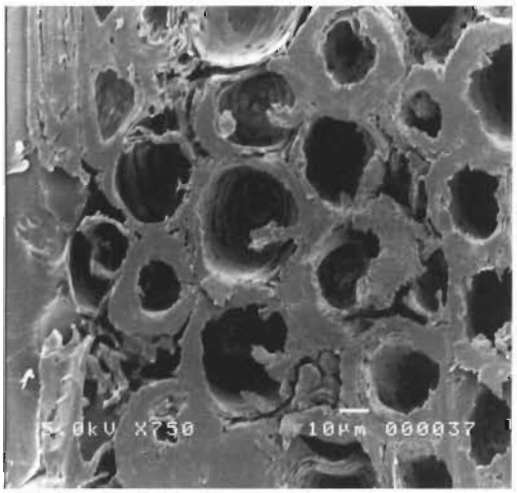
Bujang, K.B.; Jolhiri, P. and Ishizaki, A. (2000). Effects of pH on Production of Lactate From Hydrolysed Sago Starch Utilising *Lactococcus lactis* IO-1. *ICBiotech. Osaka Univ. Japan* (14): 27-31.

Bujang, K. B., Adeni, D. S. A. and Jolhiri, P. (2000). Effects of Starch Concentrations and pH on Enzymatic Hydrolysis of Sago Starch. *ICBiotech. Osaka Univ. Japan* (14): 32-35.

K.B. Bujang and S. Jobli (2002). Effects of Glucose Feed Concentrations on Continuous Lactate Production from Sago Starch. Inter Symp. 'Tropical Bio-Resources and Green Chemistry Strategy'. *ICBiotech, Osaka University.* pg:358-363.

LIGNIN-BASED BINDER FROM SAGO BARK FOR FIBREBOARD PRODUCTION





Studies carried out elsewhere highlighted the possibilities of combining sago bark and sago repos *(hampas)* for making particleboard. However, it was found that the material cost for making particleboard from these sago waste was almost twice as much as that made from wood. This was mainly due to the high content of extractives in sago waste that tended to increase the amount of adhesive used. Aside from that, physical and mechanical tests indicated that these sago wastes did not produce good quality particleboard through. The potential of utilizing lignin as a source of binder/adhesive for many applications has been widely acknowledged. Ligneous residue in sago bark (37.7%) is higher compared to wood (18 - 33%). There are many documented research on lignin-based binder from other types of wood species, mainly utilizing lignosulfonate (from sulphite pulping), organosolv lignin, kraft lignin and many others. However, none has been carried out on lignin extracted from sago bark. Enzyme induced polymerization of lignin in the wood fibres through cross linking of phenoxy radicals during fibreboard processing has been reported. Thus, attempts are now being made in utilizing oxidative enzyme for *in vivo* exploitation of lignin in sago bark for fibreboard production. The study involves determination of lignin composition and other derivatives in sago bark at different growth stages and explore the feasibility of *in situ* chemical modification of sago bark derived lignocellulose to achieve an *auto binding* properties during fibreboard processing. It is expected that the *in situ* modification will result in the formation of a resinous matrix in which the fibres are binded together by either mechanical entanglement or covalent cross linking upon curing of resin during fibreboard processing.

Researchers

Nurleyna Yunus (CRAUN), Murtedza Mohamed (Unimas), Abd. Manan Dos. Mohd. (CRAUN)

UTILIZATION SAGO BARK WASTE FOR VALUE-ADDED PRODUCT

Sago bark is one of the waste materials in the sago production industries. The locals use the barks of the trunk as timber fuel, temporary walls, ceilings and fences. At present, sago barks are processed through bio-composite method to produce sago plywood and particleboards, which have potential in building material. However the process does not utilize the natural feature and the beauty of the surface of sago bark. The basic technological properties in term of anatomical, physical chemical and mechanical properties were reported by Prayitno as follows: The diameter range of sago trunk is 41cm - 51cm. The wood part thickness of the sago trunk is 10-14 and 4-8 mm for exo and endo peripheral, respectively, while the cortex thickness is about 2 mm. The average of initial moisture content of sago bark is about 104%, which is determined significantly by endo peripheral portion. High density of sago bark, which is about 0.8 is determined significantly by the exo peripheral structure. The total swelling of sago are 0.3%, 4% and 4% for longitudinal, tangential and radial direction, respectively. This research is looking into the reuse of waste sago bark by utilizing the waste through various processes and bonding them with resin and making them into commercial products. The aim is to create products that involve recycling waste sago barks into value added products that is good in aesthetic appearance, performance and reliability. Through the exploitation of sago bark waste, a promising materials resources to be used for global environmental conservation and sustainable development.

Researcher
Khairul Aidil Azlin Abd Rahman

Supporting Grant
Fundamenetal Research Grant No. 03(57)/499/2004(236)

GROWING *MIDING* AS A CROP ON PEAT SOIL

Paku miding, the tender frond tips produce from the miding plant *Stenochlaena palustris* (Burm. (Bedd.)) has become a delicacy enjoyed especially by the local people of Sarawak. Because of its surges in popularity, there is potential for the crop to be cultivated on a commercial scale particularly on idle peat soil areas. Exploratory studies on the cultivation, handling and storage of miding is being carried out at Unimas with a view of sustaining the quality and freshness of *paku miding* for export. Miding can be propagated from the spores or vegetative parts such as the rhizomatous stems. Miding is adapted to grow in various types of soils and conditions, from lowland acid sulphate flats, peat swamps to hilly mineral soils. The area chosen for growing miding should be moist to wet and near to a water source to get good yield. About 10,000 plants are required for a quick establishment of a one hectare plot. Miding does not require much manuring. Miding may be planted on flats or trained to climb posts or other suitable structures that will allow more surface area to enhance yield. The average annual yield of fronds or *paku miding* obtained from a miding plot established on mineral and acid sulphate soils is 5-18 mt/ha. An estimated RM5000 is required to established one hectare of miding. Most of this is used in the purchase of posts and harvesting. Part-time or family labour for harvesting can reduce cost of production. If sold at farm-gate price of RM4-8/kg for Grade A curl-fronds, a net margin of RM2-4/kg can be expected.

Researchers

Petrus Bulan

Selected Publications

Bulan, P. and Storie E. 1999. Growth and production of fronds in *Stenochlaena palustris* Burm. (Bedd.) in peat soil. Proceedings of the National Horticulture Conference 99'. 16-17 November 1999, Kuala Lumpur.

Maria, J. 2002. Pengaruh kandungan kelembapan dan suhu terhadap kebolehidupan pelepah *Stenochlaena palustris* Burm. (Bedd.). BSc. Thesis. Faculty of Resource Science and Technology, Universiti Malaysia Sarawak, Kota Samarahan, Sarawak.

Storie, E. 2005. Ecophysiology and propagation of *Stenochlaena palustris* Burm. (Bedd.). MSc. Thesis. Faculty of Resource Science and Technology, University Malaysia Sarawak, Kota Samarahan, Sarawak. (write-up in progress).

IN VITRO PROPAGATION AND COMMERCIALIZATION OF WILD GINGER

The increasing demand on aromatic oils of ginger for making condiments, perfumes, and stimulants as well the oleoresin has realized the need for more supply of raw material in the market. Borneo has been identified as one of the major habitat for most of the species in the Zingiberaceae family. Many of Borneo gingers are still in the wild. These include many species of *Zingiber, Curcuma, Kaemferia.* It is well known that breeding/cultivation of ginger is a major handicap due to poor flowering and seed set. This has limited the present crop improvement programs of this species confined to the evaluation and selection of naturally occurring clonal variation. However, only a few attempts had been made to explore the potential of vegetative technique, especially, in vitro culture as an alternative tool for propagation and crop improvement. Hence, the objectives of the study include:-

(a) establishment of tissue culture protocol to conserve wild ginger of Borneo, and
(b) production of large quantity tissue-cultured plantlets (ginger seedlings) for commercial planting

The expected output of the project would include a good working protocol for ginger propagation via tissue culture and an established techniques for mass production of the ginger seedlings.

Researchers

Hamsawi Sani (Unimas) and Sim Soon Liang (Unimas)

Supporting Grant

MOSTI Insdustrial Grant Scheme (IGS) between: Malesiana Tropicals Sdn Bhd and Universiti Malaysia Sarawak

LEONURUS SIBIRICUS L. (KACANG MA) - A POTENTIAL MEDICINAL HERB IN SARAWAK

Leonurus sibiricus L (Kacang ma) is a popular medicinal herb among the Chinese and Malays in Sarawak. This annual herb belongs to the family Lamiaceae which is believe to be originated from NE Asia and Japan. It is used to stimulate blood circulation, to treat fever, good for eyes and the stems and leaves are mixed in chicken soup consumed by mothers during the confinement period. *L. sibiricus* has pink flowers and its variety *L. sibiricus* var. *albiflorus* has white flowers. In attempt to get more information on these plants the following studies are being conducted; morphological variation, flavonoid contents, floral biology and pollination and the genetic inheritance using PCR base genetic marker. Cross and self pollination tests are also being conducted for the two varieties to produce the F1 generation. These information are important before any attempt of mass production of *Leonurus sibiricus* in the future. Further study is also needed to select the suitable varieties and mass propagation for commercialisation.

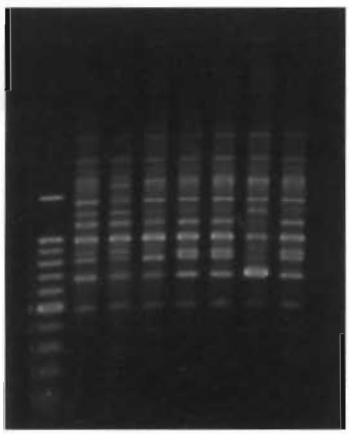
Researchers

Currently, our final year student Freddy Yeo Kuok San is doing the project on the Floral and Breeding System of *Leonurus sibiricus* supervised by the following researchers:- Cheksum S. Tawan (UNIMAS) & Sim Soon Liang (UNIMAS), Ho Wei Seng (UNIMAS) and Lau C.Y. (ARC).

Supporting grant

We are looking for grant to continue this project.

GENETIC ASSESSMENT OF PEPPER GERMPLASM USING DNA MARKERS FOR IMPROVEMENT AND VARIETY IDENTIFICATION



Pepper *(Piper nigrum L.)* is one of the most important commodities to Sarawak. It ranks second in the State's export earnings after oil palm. Sarawak is the main pepper producing state in Malaysia, contributing about 98% of the country's total production. The main areas are concentrated in the central and south-western parts of the State; i.e. in the Sarikei, Kuching, Samarahan and Sri Aman Divisions. Currently, there are about 45,000 farm families involved in pepper cultivation. The pepper variety identification in most of the breeding programs is mainly based on the morphological characters or markers such as leaf area, leaf shape, spike length, number of spikes per lateral branch and etc. In 1995, the descriptor lists based on morphological characters have been developed by IPGRI and used to characterize some of the pepper varieties in India, Indonesia and Malaysia. However, these morphological markers are largely subjected to environmental conditions and human judgement. For instance, the variety Kuching (from Sarawak) is known as 'Singapura' in Sri Lanka and Brazil. Nevertheless, these limitations can be eliminated by the use of DNA-based marker technologies. They are developmentally stable and not influenced by the environmental factors. Therefore, this project is aimed at determining the genetic relatedness of various accessions of pepper and other *Piper* species maintained at Agricultural Research Centre (ARC), Semongok using DNA based-markers, e.g. RAPDs, DAMD-PCR and SCARs, and also to establish the DNA based-marker systems specific for pepper hybrid identification. By developing the DNA-based marker systems that detect differences in DNA sequences between varieties, highly specific marker profiles can be developed for each variety and used for marker-assisted selection (MAS) and variety identification, which will provide protection of breeders' right. To date, these marker systems have been widely used to produce species-specific molecular markers for identification, validation of plant materials, and marker-assisted selection in wheat, rice, and other commercial crop species.

Researchers

Ho Wei Seng (UNIMAS), Sim Soon Liang (IHCM, UNIMAS), Paulus Amin Det (Agricultural Research Centre, Sarawak), Hajah Rosmah Jafar (Agricultural Research Centre, Sarawak), Lau Ee Tiing (UNIMAS)

Supporting grant

UNIMAS Short-term Research Grant: 01(79)/410/2003(147)

Related publications

Ho, W.S., Lau, E.T., Sim, S.L., Paulus, A. & Hajah Rosmah, J. 2005. DNA fingerprinting of pepper using polymerase chain reaction with the M13 universal primer. Paper to be presented at the 6th National Congress of Genetics, 12 - 14 May 2005, Kuala Lumpur.

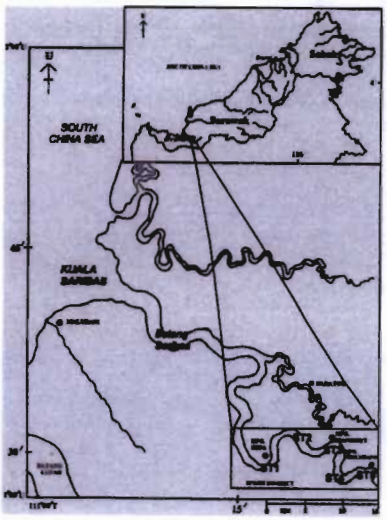
STUDIES ON THE AQUACULTURE POTENTIAL OF RAZOR CLAM

Ambal or razor clam are soft bottom infaunal marine bivalves with more or less narrow and long shells, gaping at both ends (fig). They prefer intertidal sandy beaches or sandy bars of western part of Sarawak namely Buntal, Bako, Muara Tebas, Sambir, Sebandi, Moyan Laut, Serpan and Asajaya Laut. The *Solen* spp. also occurs in other areas in Sarawak including Sematan, Lundu, Kabong and Kuala Matu. The local market price for ambal is ranging from RM12 to RM18/ kg. However information on its taxonomy, biology and population dynamics has not yet been properly documented. This project comprises four main research areas including: (i) ecological study and population dynamics, (ii) complimentary use of morphological and genetics data in systematics, (iii) ecotoxicological and heavy metal study, and (iv) larval biology and artificial seed production for aquaculture. The study will begin with mapping the diversity and population dynamic of several ambal species in Kuching Bay. Simultaneously, physico-chemical factors of their natural habitat will be recorded. In addition, the feeding behavior and food taken by the ambal will be analyzed and documented. To-date, there are three known species of genus *Solen* in which one of them is believed to be new. In this project, molecular data will be generated to compliment the available morphological information in clarification of ambal systematics. As ambals are filter feeders; there is high tendency for ambal to accumulate toxic compounds via bioconcentration and biomagnification pathways, making them potentially dangerous for consumers. This project is essential to determine the content of toxic compounds in ambal and the surrounding sediments. The information is crucial for identifying suitable areas for future ambal cultures as well as urgent need to properly document the safety level of ambal consumption in Sarawak. In summary, data gathered in this project will be useful in future projects including establishment of ambal aquaculture, maintaining natural ambal stocks, identifying potential species for bioindicators and endangered species.

Researchers

Siti Akmar Khadijah, Ruhana Hassan, Devagi Kanakaraju & Shabdin Mohd. Long

ECOLOGY AND FECUNDITY OF PUFFER FISH *XENOPTERUS NARITUS* (TETRAODONTIDAE) IN BATANG SARIBAS, SARAWAK



Puffer fish live in marine habitat with several entering and occurring in brackish and freshwater; tropical and subtropical Atlantic, Indian and Pacific Ocean. A study on the ecology and fecundity of puffer fish, *Xenopterus naritus* from the family of Tetraodontidae was carried out in Batang Saribas, at five selected stations; Kampung Supa, Tanjung Keranji, Kampung Manggut, Tanjung Baring, and Kampung Serembang. Congregation of puffer fish in Batang Saribas is mainly due to spawning activities. Contrary to the local knowledge that small sized individuals are juveniles, they are actually mature males. The total length for male puffers (14.46 ± 1.58 cm) was significantly shorter (P=0.0001) than female puffers (23.88 ± 1.8 cm). Male were also significantly lighter than female (P=0.0001). The average of male body weights was 87.4 ± 29.52 g, while for female it was 476.94 ± 121.04 g. The average ovary diameter was 2.74 ± 0.51 cm while the average ovary length was 6.87 ± 1.02 cm. The average volume of eggs was 67.58 ± 28.89 ml while the number of eggs was 8855 ± 3764. The average size of eggs was 2.67 ± 0.14 mm. In the male, the average testis diameter was 0.61 ± 0.11 cm and testis length was 1.39 ± 0.23 cm. Gonadosomatic indices for females (30.9 %) is significantly higher than male (5.24 %). The puffer fishes are also known to have economical value. They are consumed for food and commercially sold by the villagers to outsiders as source of income. The fresh fishes are sold at RM3 per kilogram for smaller size and RM1 per fish for bigger size. The puffer fishes could be freshly prepared and cooked, salted, dried or fermented. The salty dried egg is a delicacy and can fetch a very good price at more than RM30.00 per kilogram. The State Government of Sarawak had launched the Puffer Fish Festival at Kampung Manggut, Betong since 2002. Considering the commercial and cultural values of this species and the annual activities of catching the puffers during spawning season, it is particularly important for detailed studies to be conducted with regard to its ecological, biological and conservation aspects to prevent this species from dwindling.

Researchers

Lee Nyanti and Regina Kristy ak Nohan (Unimas).

Supporting grant

Unimas Fundamental Grant No. 01/48/328/2002 (65).

Related publications

Coull, J.R. 1993. *World Fisheries Resources*. Routledge Publication, London.

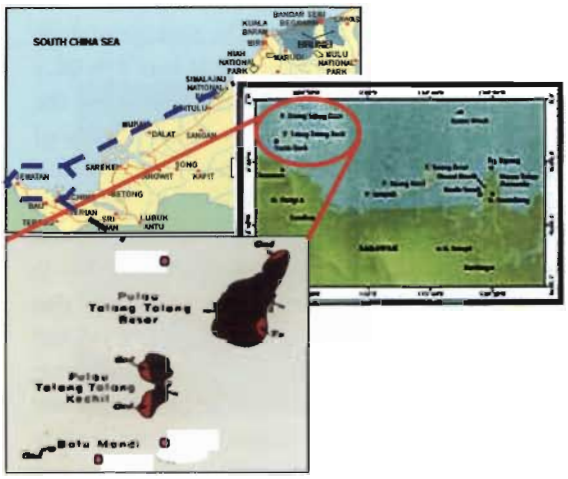
Gordon, M.S., Plaut, I. and Kim, D. 1996. How Puffers (Teleostei: Tetraodontidae) Swim. *Journal of Fish Biology* **49:** 319-328.

Jenning, S., Kaiser, K.J. and Reynolds, J.D. 2001. *Marine Fisheries Ecology.* Blackwell Science Ltd., London.

Kana, I. 2002. Pesta Ikan Buntal. *Rakan Sarawak,* Sarawak.

Moyle, P.B. and Cech, J.J. 2000. *Fishes, An Introduction to Ichthyology.* Prentice Hall, Inc., New Jersey.

DISTRIBUTION AND DIVERSITY OF FISHES AT ARTIFICIAL REEF BALLS AROUND TALANG-TALANG ISLANDS, SEMATAN: IMPLICATIONS ON COMMERCIAL FISHERIES



Artificial reefs are designed with specific goals such as to create new habitat on the seafloor for reef creatures, breeding area, place to seek protection from predators as well as to provide a substrate for reef fouling communities, which create a food source for primary and upper level consumers. Many different materials have been used to create artificial reefs. In Talang-Talang Island, a concrete reef ball was used. Concrete has been found to be very favourable for artificial reef construction. It does not degrade in seawater, can be made to have neutral pH, is easily molded, not easily moved once in place but harder to transport to the deployment site. Concrete can be made to have a texture comparable to natural reefs and develops very similar communities as natural reefs. A study was carried out at Talang-Talang Islands where artificial reef (i.e. reef ball) have been deployed since 1998. This study was carried out to evaluate the potential of reef ball as a new habitat and its effectiveness in increasing the productivity of the area and diversity of fish fauna. The results show that reef balls that were deployed in 2002 have the highest number of species (33 species) compared with the nearby natural reef (26 species). Although the natural reef area have the highest number of individuals of fish (6,640 individuals) compared with the reef balls (1,631 individuals), reef balls deployed in 2002 have more fish species of commercial value such as *Epinephelus* spp., *Lutjanus* spp., *Lenthrinus* spp., *Lates* sp., and *Rastrelliger* sp. In contrary, the nearby natural reef have more none commercial species of fish. These results show that artificial reef is an effective way to increase fish diversity and increase the number of commercial fish species.

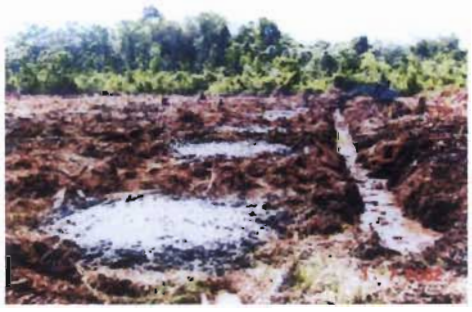
Researchers

Lee Nyanti and Nazzatul Asyikin Mohd. Najib (Unimas) in collaboration with the Sarawak Forestry Department and Department of Marine Fisheries.

Supporting grant

Faculty of Resource Science and Technology (FRST), Unimas and Department of Marine Fisheries.

ENVIRONMENTAL IMPACTS AND IMPACT ASSESSMENT OF PEATLAND DEVELOPMENT IN SARAWAK



A substantial area of peatland in Sarawak has been developed and reclaimed during the last few years. More peatlands, including deep peat areas, are expected to be alienated for oil palm and planted forest plantations in future. Peat swamp ecosystem habours many species of flora and fauna. Peatland plays important ecological role especially in conserving water and controlling flood while also forms an important potable water supply source. Water is the element that governs the characteristics and behaviours of the peat. Nevertheless, drainage of excess water is a prerequisite for the reclamation of any peatland for development projects. A study was carried out to examine the potential environmental impacts of peatland development in Sarawak. The study involved collation and examination of EIA reports, literature and other documents related to peatland development, field visits to selected plantations, and interviewing of developers, environmental consultants and plantation personnel. Among the key environmental impacts identified in peatland development were the loss of biodiversity, disturbance of the water balance, peat subsidence, saline intrusion, and increased susceptibility of peatland to fire. Intensive agriculture on peatlands also resulted in the problem of agrochemical contamination of both the surface and ground water. Literature review and interviews with agencies dealing with peatland development revealed that the properties and behaviours of peat in Sarawak were inadequately understood. The piece-meal basis EIA as currently being practised was found to have serious limitations. Many EIA reports were not able to quantify environmental impacts as the history of large-scale development on peatland in Sarawak was very recent and published data on the impacts of similar development elsewhere were not readily available. Thus the EIA reports were generally descriptive in nature and the cumulative and indirect impacts of peatland development could not be assessed. Field observations and review of post-EIA monitoring reports revealed the lack of compliance of the developers in observing the mitigation measures as stipulated in the EIA report or approval documents. The management knowledge of peatland amongst the plantation managers was limited, thus "trial and error" approaches were invariably applied in the peatland plantation management.

Researchers
Murtedza Mohamed (Unimas), Ten W P (NREB)

Supporting Grant
European Union INCO-DEV NO: ICA4-CT-2001-10098

Publication
Paper presented at the International Research Seminar on Strategies for Wise Use of Tropical Peatlands - the Sarawak Context. 24 November 2004, Kuching, Sarawak.

HUMIC ACIDS DERIVED FERTILIZER PRODUCTS FROM PEAT WATER AND OTHER LIGNO-CELLULOSIC SOURCES

Humic acids and its derivatives have been extensively mined from peat for agriculture use, particularly in horticulture industries such as those in the Netherlands. Extraction of humic acids from peat is not sustainable and the environmental impacts of the excavated peatlands will be enormous. This project was focusing on the extraction of humic acids from sources such as peat water as well as lower energy and low quality coals (lignite). Both these sources are considered as "wastes" in their respective sectors. Extraction of humic acids from these "wastes" material will redefine them as valuable resources. The general objectives of this project were to determine the economical sources of humic acids and reformulating the humic acids into specialized fertilizers such as the slow release type.Specifically, the project was focusing on:

a) the optimized humic acids extraction procedures from peat water
b) the optimized humic acids extraction from poor quality coals
c) the formulation of humic acids based slow release fertilizers.

Humic acids from peatwater treatment plant at Asa Jaya were collected and characterised. The humic acids content in peatwater was low and as of now, it is not economical to upgrade this extraction to a commercial scale. However the potential as a source of humic acids still remains. If water supply in the future needs to use peatwater in huge quantity then it may be economical as the humic acids would be the by-products of the treatment plant. The extraction of humic acids from coal showed great potential. Through nitration with nitric acids, the yield of nitrohumic acids was in the range of 80%. Such a high yield would make it economical for commercial production of nitrohumic acids from low quality coals. There are several large deposits of such lignite coals in Mukah as well as Kapit area. The project is currently looking at ways to incorporate nutrients and micronutrients for variety of plants/crops into the humic acids based fertilizers.

Researchers:
Wong Nam Chong (Mardi), Lau Seng (Unimas), Janice Asing (Mardi), Sim Siong Fong (Unimas) and Amira Satriwaty Md Pauzan (Unimas).

Supporting Grant:
IRPA (01 - 03 - 03 - 0107 EA 001)

Related Publications:

J. Asing, N.C. Wong and S. Lau, 2004. Preliminary method development of humic acid extraction. Proceedings Soil Science Conference, Kuala Lumpur 2004. pg. 4.

Amira Satirawaty Md. Pauzan, 2004. Extraction and characterization of humic acids from peat water and coal. BSc. Thesis, Unimas.

FROM WASTE TO USEFUL BY-PRODUCT: STUDY ON POSSIBLE USE OF SHELL MDS BIOSLUDGE AS SOIL CONDITIONER

Shell Middle Distillate Synthesis (Malaysia) Sdn Bhd (SMDS) produces partially digested sludge or biosludge (containing mainly wastewater and some soot) from the cooling tower. Currently, the solid waste (separated by centrifugation) is disposed at the Bintulu Development Authority (BDA) dumpsite at a rate of 5-10 tonnes/ day. An alternative disposal method was tried on pilot scale by composting the sludge with another waste product, namely, wood shavings from the timber industry (on a 1:1 fresh mass ratio) using a simple windrow system. The goal was to produce composted biosludge that can be safely and legally used as a soil conditioner. Composting for a month generated mature compost (Germinating Index higher than 70%) with minimum (one third) reduction in fresh weight. Extending the processing period for another 10 days reduced the compost to about half the combined fresh weight of the original materials. The compost (SMDS Compost) was amorphous-granular in nature with particles or granules of sizes smaller than 2 mm making up almost 75% of its total mass. Having reasonable concentrations of fertilizer nutrients (2% N, 0.3% P and 0.16% K), moderately high exchange capacity (30 $cmol_c kg^{-1}$), a favourable C/N ratio (22.5), an almost near neutral pH (6.7) and the ability to promote soil aggregation, it possessed essential properties of a soil fertilizer-conditioner. Heavy metal concentrations and pathogen populations in the compost as well as leaching of the metal ions from compost-applied soils were all below the international and Malaysian regulatory limits for safe use. The compost can therefore be classified as Exceptional Quality material, suitable for land application in agricultural and horticultural productions without any restriction. In carefully designed pot and field trials, the compost was found to significantly improve seed germination and early growth of selected vegetables and flowers. The concentration of heavy metals in the vegetables grown on the SMDS compost-applied soil were well below the tolerance levels. An accompanying market study revealed a great and growing demand for compost and organic fertilizers in Bintulu as well as Sarawak in general. Based on these findings it was concluded that there is potential for the SMDS biosludge to be processed into compost and distributed commercially. For improved quality and marketability of the finished product, however, the composting process should use a more uniform-sized bulking material. The product should also be fortified with phosphorus and potassium (inorganic forms) and perhaps nitrogen according to specific market needs.

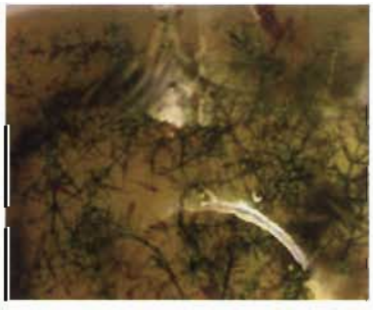
Researchers

Wan Sulaiman W.H., Bujang, K.B., Bulan, P., Sanggin, S.E, Kasing, A., Sim, U. H., Zaini, A., Sepiah, M. and J. Sinsoon (UPM)

Supporting grant

Collaborative Unimas - Shell MDS Sendirian Berhad, Bintulu.

DETERMINATION OF PESTICIDES RESIDUES ON VEGETABLES AND ITS PATHWAYS TO THE AQUATIC ENVIRONMENT



The application of pesticides in agriculture, particularly in vegetable farming is generally essential for a viable production. However, over usage of pesticides would be detrimental to our health and as such the Agriculture Department is continuously monitoring the pesticides residues in vegetables. The tradition analytical procedure is rather complicated and use large quantity of organic solvents. The disposal of these solvents has become an environmental issue. Our laboratory has successfully developed a reliable and yet simple procedure for routine analyses of pesticides residues in vegetable. The usage of Solid Phase Extraction (SPE) technique has enable the analysis of pesticides be done faster and most importantly has reduced the usage of organic solvent by more than 50%. This analytical technique will allow the Department to conduct more thorough screening of vegetables to ensure public health safety. The application of pesticides will inevitably affect the aquatic environment as the pesticides will find its way to the water bodies. One of the main pathways for pesticides to enter the water bodies is through surface runoff. Other pathways include seepage through groundwater and spillage of direct discharges of pesticides from warehouses or storage areas. The weather conditions in Sarawak are such that it rains heavy and frequently. Therefore, the potential of newly sprayed fields being washed out by rain is relatively high and common. A study on the rate at which pesticides are being washed from the vegetable farms into the water bodies through surface runoff was carried out. Several factors that may have influence on the runoff rates were studied. These factors include, the time interval between pesticides application and the first rain event, the intensity of the rain and the amount of pesticides accumulated in the soil. This study has shown that a significant proportion of the applied pesticides will be washed out in the surface runoff if it rains within 2 hours after the pesticides was applied in the field. The amount washed out was also proportional to the rainfall intensity. If the time interval between pesticides spraying and the first rain event exceeds 4 hours, the pesticide residues that were washed out was less that 0.5 % of the applied amount. This project will be extended to study the management of surface runoff from vegetable farms to prevent pesticides contaminations of the nearby waterways.

Researchers:

Lau Seng (Unimas), Alvin Chai Lian Kuet (ARC) and Tay Teck Pin (Postgraduate Student).

Supporting Grant:

Postgraduate research grant.

Related Publications:

Chai L.K., and Lau, S. 2003 Determination of organophosphorus pesticides in vegetables by solid-phase extraction cleanup and gas chromatography. *Pertanika J. Sci. and Technol.* **11(1):** 93 - 105

Chai L.K., and Lau, S. 2003 Determination of pyrethroid pesticides in vegetablesby solid-phase extraction cleanup and gas chromatography. *Pertanika J. Sci. and Technol.* **11(1):** 107 - 117

Alvin Chai Lian Kuet and Lau Seng. 2003. Determination of organochlorine pesticides in vegetables by SPE cleanup and GC. *Pertanika J. Sci. & Technol.* **11(2):** 249 - 259.

CARRYING CAPACITY OF AN ESTUARY FOR AQUACULTURE

The agriculture sector in Sarawak is an important contributor to the State economic growth. In recent years, tiger prawn farming has received tremendous interest and requests for licenses to operate the farms have been plentiful. The Agriculture Department is facing a problem in relation to how many licenses can be issued within a river basin. The carrying capacity of the estuary should be used to determine the number of licences for prawn farms that should be issued. At this point in time there is no guideline or indicators for estimating the carrying capacity. This project was being conducted to focus on the impacts of prawn farming on the estuarine aquatic environment and the estimation of the carrying capacity of the estuaries with respect to the aquaculture industries. The general objectives of the project are to develop a practical method to assess the health of a river basin and to determine its carrying capacity. Specifically, the project has focussed on the following goals:-

i) to assess the sediment quality of several estuaries with respect to enrichment of organic matter, BOD and its nutrient release capacity
ii) to develop an assessment tool for determining the carrying capacity of a river basin based on sediment analyses.
iii) to identify the indicator parameters for estuarine sediment quality assessment.

The principal methodology for this research was through the collection and analyses of sediments for their organic carbon contents. Sediment trap has been fabricated which was capable of measuring the sediment load in the aquatic environment. This device is robust and easy to deploy and the results obtained were reliable. The carrying capacity of a river system/estuary can be consistently estimated by the rate and contents of the organic matter in the sediment. Comparison between the sediment core from the riverbed and the freshly collected sediment from the sediment trap has provided a good indicator for the status of the carrying capacity of the river basin. Currently we are attempting to correlate the organic matter contents in the sediment with the yield of prawns from the study area. Monitoring the organic matter enrichment rate in the estuarine sediment enables the estimation of the carrying capacity of the river basin. The monitoring procedures have been simplified through the use of the sediment traps, which will be suitable for implementation by government agencies as well as private individuals.

Researchers

Lau Seng (IBEC), Tay Meng Guan (FRST) and Alvin Bong Chee Hong (Postgraduate Student)

Supporting grant

Unimas research grant: 1/67/398/03 (135)

Publication

Alvin Bong Chee Hong, 2005. *Determination of the carrying capacity of an estuary for aquaculture.* MSc Thesis. UNIMAS *(In progress)*

MANAGEMENT OF EFFLUENT FROM SHRIMP FARM: THE ROLE OF SEDIMENTATION POND

Large amount of effluent from shrimp farms are discharged into the adjacent water body such as river or estuary through routine water exchange, overflow during heavy rainfalls and draining of ponds during harvesting. The impact of effluent from shrimp ponds on the environmental quality of adjacent water bodies is proportional to the discharge volume and nutrient concentration. Poorly regulated shrimp industries have resulted in complete or partial collapse of shrimp industries in Taiwan, Thailand, China and Ecuador. Because pond effluent contains nutrients, organic matter and suspended solids that could result in eutrophication, sedimentation and other pollution problems in the receiving water, management of effluent has gained importance in aquacultural waste management over the last few decades. The goal of this study was to determine the role of sedimentation pond in the treatment of effluent from shrimp ponds. This study was carried out at a commercial shrimp farm in Kuching area. Effluent discharged from the shrimp ponds during harvest were analyzed at every interval of 10 cm of decrease in pond water levels. Water samples were also taken from the sedimentation ponds after the completion of harvest to monitor the changes in the effluent water quality through time. The concentration of soluble reactive phosphorus, turbidity, total suspended solids and biochemical oxygen demand were significantly higher at the pond bottom water ($P < 0.05$). Effluent water quality improved significantly after retention in sedimentation pond for about 16 hours. There was a decreased of 48% in concentration of ammonia nitrogen, 92% in soluble reactive phosphorus, 79% in turbidity, 55% in total suspended solids, 45% in biochemical oxygen demand and a decreased of 30% in dissolved oxygen. To reduce the problem of space and limitation of sedimentation pond to contain large volume of effluent, it is proposed that only the second last portion (about 50%) of effluent be diverted into the sedimentation pond for retention. Therefore, shrimp operators should seriously adopt the use of sedimentation pond to reduce the input of nutrients into the surrounding water bodies. Discharge of untreated effluent will cause shrimp farming to become unsustainable because there will come a time when the development of shrimp industry exceeds the carrying capacity of the environment. The present guidelines requiring all effluent be retained for a period of 72 hours in sedimentation pond may need to be reviewed after a more detail study is carried out. Retaining only the last portion of the effluent for a shorter period of time would reduce the problem of space and limitation of the sedimentation pond in containing a large volume of effluent.

Researchers
Lee Nyanti, Soon Yit Leng, Lau Seng and Ling Teck Yee

Supporting grant
Unimas Fundamental Grant No. 247/2001 (6).

ASSESSMENT OF BRACKISH SHRIMP FARMING IN SARAWAK AND ITS IMPACT TO THE ENVIRONMENT

Shrimp aquaculture has grown rapidly world wide in the past three decades. In Malaysia, the number of shrimp farms and farming areas has also increased steadily over the years. Given the extensive potential areas for shrimp farming and the support from both the government and the private sectors, the future prospect of shrimp farming in Malaysia is promising. Sarawak has great potential in shrimp farming due to tropical climate characterized by high temperatures throughout the year and a vast coastline extending about 1,051 km. The abundant aquatic resources, relatively underdeveloped coastal land and generally unpolluted water resources, cheap and easily trained labor forces, existing government policies and natural conditions in Sarawak are favourable for the development of aquaculture. However, activities associated with aquaculture such as land clearing, excavation, feeding, fertilization, and effluent discharge are likely to have impact on water quality in the surrounding environment. Water discharges from shrimp farms have been known to contain high loads of nutrients and suspended solids. Although the receiving water bodies have a capacity to dilute and assimilate the pollutant to a certain extent, eutrophication and other environmental problems could occur if that capacity is exceeded. The aim of this study was to assess the effects of different management practices in two brackish shrimp farms in Sarawak and input of nutrients into the surrounding environment. Water quality (physical and chemical) was monitored in two commercial shrimp farms, which practised open system and semi-closed system, and in estuaries adjacent to the farm. Nutrients flushed from the shrimp ponds into the receiving waters during water exchange were also quantified. Results showed that in both farms, pond water have relatively higher concentrations of ammonia nitrogen, total suspended solids and excessive growth of phytoplankton as the shrimp culture progressed. Water exchange rate of 15% of pond water volume in semi-closed system was sufficient in improving water quality of the pond, instead of 30% of pond water volume. The results of this study also indicated that semi-closed system of shrimp farming is more environmental friendly compared to the open-system based on water exchange practice and the contributions of nutrients to the adjacent water bodies. Farms practising daily water exchange is more destructive to the environmental because they discharge more pollutants into the receiving waters.

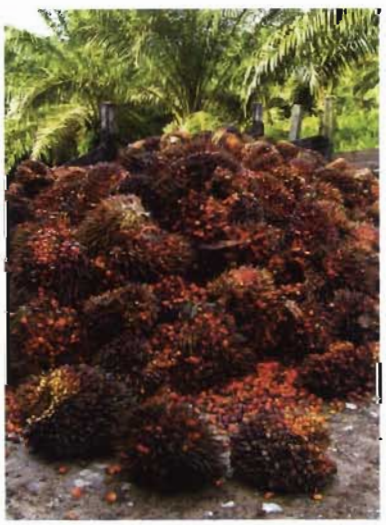
Researchers
Lee Nyanti and Ting Chai Hong (Unimas)

Supporting grant
Unimas Fundamental Grant No. 247/2001 (6).

Related publication

Nyanti, L., Soon, Y.L., Lau, S. and Ling, T.Y. (2001). Management of effluent from shrimp farm: The role of sedimentation pond. *In Proceedings of The Regional Conference on Natural Resources and Environmental Management.* pp. 158-168.

PLANTATION MANAGEMENT AND DECISION SUPPORT AND PLANNING SYSTEM



UNIMAS has signed a Memorandum of Understanding with SALCRA on the 2nd September 2004, with the aim of setting up a Plantation Management Information System (PMIS) and Plantation Decision Support & Planning System (PDSPS). This project will be carried out in two phases:

a) Phase 1 - Establishment of GIS Database for SALCRA
b) Phase 2 - GIS Application Development for PMIS and PDSPS

The lack of accurate hectarage information for the areas planted with oil palm in the estates may result in inaccurate computation of dividends payable to the participating landowners, and the estate's productivity measures computed based on this information. Furthermore, the recording for detailed maintenance, harvesting, and survey data have not been digitised, and therefore the management are unable to effectively monitor field activities conducted in the oil palm estates. The management also requires a computerised system that can assist in the planning and decision making processes, as well as for forecasting and budgeting purposes. s such, the objectives of this project are

i) To establish specific programs on GIS related to the oil palm environment and any other areas of interests as nominated by SALCRA
ii) To establish a GIS database for SALCRA oil palm estate
iii) To develop a system for the management of oil palm plantations employing GIS technologies for planning, monitoring operating and decision-making.
iv) To develop and enhance the image processing of satellite and aerial photographs, and to apply such enhancements in the systems developed.
v) To provide training related to spatial data acquisition techniques, and the use of GIS application developments.

Ongoing research for this project will focus on improving the cost-effectiveness of establishing the GIS database for SALCRA, which include research on the use of IKONOS image and GPS survey data to compute the actual area planted with oil palm in the estates. Other research related to this project includes optimised re-districting of the block boundaries using multi-criteria decision-making, and the extraction of parcel corner from the scanned cadastral maps using imaging-processing and artificial intelligence techniques.

Key Researchers

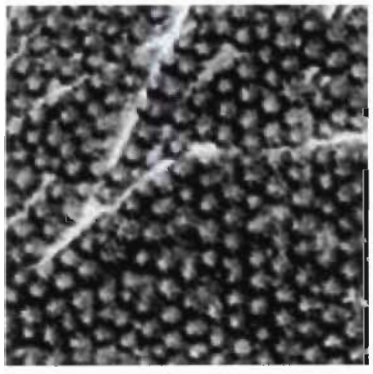
Wang Yin Chai, Alvin Yeo, Jane Labadin, Chai Ted Sing

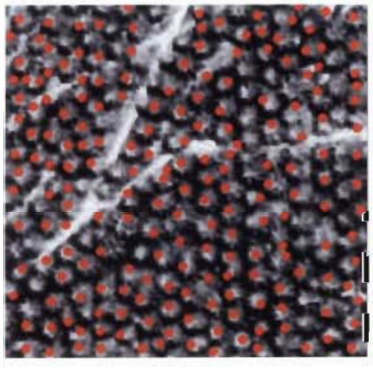
Related Publications

Bong Chin Wei and Wang Yin Chai (2002), Incorporating Fuzzy Multicriteria Decision Support in GIS based Forestland Zoning, International Conference on Artificial Intelligence in Engineering and Technology, ICAIET 2002, Universiti Malaysia Sabah, Kota Kinabalu.

Chai, T.S. and Wang, Y.C. (2001). Incorporating Intelligent Technique in Improved Hough Transform For Land Parcel Extraction. National Artificial Intelligence Seminar (AIS2001), November 1-3, 2001. Universiti Utara Malaysia in collaboration with Prince of Songkhla University.

OIL PALM TREE CROWN DELINEATION AND ENUMERATION USING IKONOS SATELLITE IMAGES





Manual interpretation of medium and high spatial resolution aerial imagery for forestry has evolved during the 20th century. For this type of application, manual delineation and enumeration of the tree crowns on the aerial images are the main activities required. Of late, a new research branch which aims at fully or partly replace human image interpreter by a "seeing computer" was born. The application of image processing techniques in delineating the tree crowns on the images is being greatly surveyed and a lot of delineation techniques had emerged. The launching of IKONOS satellite, which provides very high spatial resolution to the user of this type of applications, has opened up another option of the input data, that benefits the users in many aspects. One of the most interesting applications of image processing technique is in the management of oil palm plantation. As the plantation areas are increasing in size, the management of the plantation in term of cost, time and resources saving has been a main consideration for palm oil tree plantation owner. One of the issues concern is the enumeration of the palm oil tree on the plantation with respect to species identification and health control management. This research has utilized the resolution of the IKONOS satellite image for palm oil tree delineation and enumeration purpose in replace of aerial images, which was once a favorite and common input data for this application. With this type of source image, this research has determined the use of smoothed curvature for better delineation of the palm oil tree crowns from the image. The use of Principal Component Analysis (PCA), which utilizes the eigenvalue and eigenvector, incorporate with the mean evolute point, of the detected points to detect the palm oil tree crowns. For these detected points, the research proposes the use of distance analysis to eliminate the redundant points detected and also to re-detect those points, which are omitted. The determination of the accepted and rejected will be next analyzed using the circle drawing method. This will eliminate points which are too far from the middle of the tree crowns. The whole process is termed as Statistical Analysis method. A prototype of the proposed model is successfully designed and developed. With human operator being used as the supervision tool incorporate with the supervision of object descriptions, the result of enumeration from the proposed model is compared with the result of the manual delineation. The average enumeration accuracy is 92.10%, with the percentage of correctly spotted tree crowns being 84.08%.

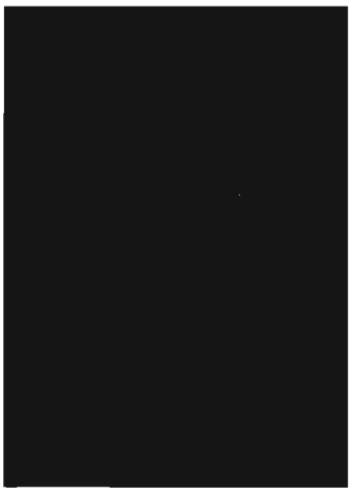
Researchers
Wang Yin Chai, Chai Soo See

Supporting grant
SALCRA

Related publications

Wang Yin Chai & Chai Soo See. Oil Palm Tree Crown Delineation And Enumeration Using Ikonos Satellite Images. Proceedings of the postgraduate colloquium in Science and Technology 2002, Kuching, Sarawak.

PERFORMANCE OF AGRICULTURAL SPRAYERS AND SPRAY CHARACTERISTICS



The design improvement of pesticide sprayers for protecting crops in the local agricultural industry and the spray characteristics are of interest in this research proposal, with a view to start up a research group that is well suited to up-to-date research on agricultural as well as combustion engine spray systems in the near future. The advancement in laser and photographic methods has enabled the spray characteristics to be studied qualitative and quantitatively. The application of electrical force in the other hand has enabled the spray plume to be manipulated for better droplets atomization and droplets deposition on the crops. Such an unconventional technique has been proven to be viable by using a charge induction technique. However, this technique is limited by low liquid flow rates. Thus, the application of other techniques such as charge injection technique with a higher flow rate will be investigated in this study. The study will combine both experimental studies on initial spray characteristics produced from such pesticide sprayer and the effect of electrical force. The aim of the study is to design an improved spray system that is well suited to the local agricultural industry.

Researchers

Andrew R.H. Rigit

Supporting grant

Unimas Fundamental Research Grant

Related publications

Rigit, A.R.H, and Shrimpton, J.S., (2004), "Characteristics of Charged Sprays Generated Using Charge Injection Electrostatic Atomizers," to be presented at 11th Int. Symp. Flow Visualizations, University of Notre Dame, Notre Dame, Indiana, USA, August.

Rigit, A.R.H., and Shrimpton, J.S., (2003), "Spray Characteristics of Charge Injection Electrostatic Atomizers with Small Orifice Diameters," accepted for publication, *Atomization and Sprays*, Ref. No: AT/EU/45.

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